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ELECTROLYSIS AND THE NERVOUS SYSTEM.

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In 1854, when a student at McGill University, my attention was directed to the marvelous operations of the nervous system, since which time I devoted spare hours to the problems of this intricate structure. Tear and wear are the result of both mental and physical strain, at no time more marked than in the present century. For many years I applied electricity in the ordinary way, frequently with beneficial results, without knowing exactly the why or the wherefore.

The power of the galvanic current to decompose water was discovered and first described by Nicholson and Carlisle in 1800. In 1806 Sir Humphry Davy presented to the Royal Society a lecture on some chemical agencies of electricity and the following year announced the discovery of the decomposition of the fixed alkalies. The phenomena of electrolysis are due to a modification, by the current, of the chemical affinity of the particles through which the current passes, causing them to undergo decomposition and recomposition. In the electrolysis of inorganic substances, it cannot be expected to solve the mysteries of life and disease. As the body is largely composed of water, holding in solution salts of potash and soda, it thus becomes an excellent electrolyte. The current of a dry battery, transmitted by an ordinary neurotone, is the simplest and most efficient method of electrical application. The

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umbilicus may be considered *the storm centre*, as far as collateral influence on the sympathetic system is concerned, as here the solar plexus approaches nearest the surface through its many filaments, which in turn accompany all the branches given off by the abdominal aorta. It also interlaces with the nerve fibres of the phrenic plexuses; gastric, hepatic, and splenic plexuses; suprarenal and renal plexuses; superior mesenteric plexus; spermatic plexuses; and inferior mesenteric plexuses. Although according to Bastion a wide basis of positive knowledge does not exist, it is accepted that the sympathetic system of nerves, with its double gangleonated cord and great ganglionic plexuses, is, to a certain extent, an independent nervous system, penetrating deeply by its roots into the cerebrospinal axis. Its fibres are conducted to and from the viscera along the course of the bloodvessels. The peripheral ganglia are dominated by a still higher regulating centre, situated in the medulla oblongata, in relation with all the vasomotor nerves throughout the system. Although the nature of its relations with the medullary centre is still uncertain, the fact that the fibres of the sympathetic are mixed up on the vessels with those having a vasomotor function and have to do with the calibre of the bloodvessels generally, take part in the activity of all the glandular organs, in the movements of all the hollow viscera, and in the nutrition of the tissues generally, places the sympathetic system in the front as a central motive power. These are the circumstances which count in the operations of the system. When the tear and wear can be so changed by electrolytic action as to afford the freer transmission of normal nerve force, the constitutional changes for the better become most marked.

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CASE I.—R. C. McC., aged seventy-one years, an officer in the Civil Service, Ottawa, was attacked, fully seven years ago, with a cough, shortness of breath, with a general sense of muscular weakness, and lessened ability to walk with usual strength of limbs, the gait being reduced to a short and rather feeble step. There was no evidence of marked muscular atrophy, but rather of defective muscular power in locomotion, and of lessened normal vigor as to contractility. This condition continued more or less for a period of fully five years. In regard to sensory functions, there were no important subjective phenomena. In the entire body all kinds of skin impressions were perceived readily and with normal acuteness. Eyes were perfect as to vision, and there was no strainess whatever; sight was acute, both as to form and color, pupils were equal and reacted perfectly to light. Motor condition was equal on both sides of the body. Knee jerks were normal, and not in any way exaggerated, also ankle clonus was normal. Voluntary movements in face, arms, and hands were tolerably well performed. The patient stood steadily, with no marked change in closing eyes. If faulty condition in the spinal cord or higher sensory tracts accounted for the short steps in his gait, the fact of there being no altered sensibility of other kinds precluded such a possibility. The general symptoms, being functional in character, favored disappearance under treatment. Anæsthesia of the mucous membrane of the conjunctiva or cornea was not at any time present. The pupils were natural in size and normal as to action, and the various media indicated no disease whatever. The gait was quite simple in character, perfectly regular, very short steps, with no signs of unsteadiness and no zizagging in leg movement. After careful consideration it was thought that the chief source of difficulty pointed towards faulty action in the nerve centres, resulting from the accumulation of tear and wear in past years, obstructing in a degree the normal transmission of nerve power. Electrolytic treatment, through the solar plexus, given every second day for three weeks, brought about an entire change for the better in every particular. The patient now walks with ease and comfort, enjoying the gait of years past. His face regained its former red color, owing to increased power of the vasa vasorum. The improvement in his general condition was most marked, appetite was good, cough and breathing much relieved, constipated bowels had become more regular. Sleep was composed and

natural. His life history showed a temperate and regular man, free from any syphilitic complication.

CASE II.—Mrs. A. K., aged eighty years, well formed and of moderate stature, generally enjoyed good health, and was the mother of one child. Five years ago, for the first time, the patient found the power of her limbs not as vigorous as usual, but this fact was not attended by pain or evidence of muscular atrophy. She was unable to walk any distance without inconvenience and rapidly developed fatigue. The symptoms were attended by considerable shortness of breath and apparent inability to expand the chest, with accustomed vigor, in the respiratory process. Cough, expectoration, or any evidence of organic pulmonary or cardiac disease were not present. At times, during the past two years, she experienced a sense of dizziness, chiefly during the night, on movement of the head, which circumstance interfered with her usual quiet rest. The other functions of the body were normal, appetite was good, bowels moved regular, and urine was voided in normal quantity. Pulse was full, easy, and regular, and not changed by altered position. Memory was still retentive, and eyesight was normal. On January 4, 1907, she was placed under treatment, which was given every second day for a period of three weeks, each application of the neurotone to the moistened umbilicus, not occupying more than ten minutes, and the power graduated according to circumstances. The change for the better in the entire system was most marked, dizziness disappeared entirely, breathing became normal, and the power of the limbs was so restored that she walked freely to church and otherwise, without any difficulty. Facial expression was quite changed for the better, and the cheeks presented a shade of color, owing to undoubted increased activity in the capillary circulation.

CASE III.—Judge F., aged seventy-nine years, father of a large and healthy family. The patient was of ordinary stature, regular conformation, and usually enjoyed vigorous health, owing to entire absence of organic disease. During the past two years there had been a general feeling of malaise, with disinclination to engage in the active efforts of business, associated with a degree of mental depression, chiefly owing to the changed habits of life. The patient was unable to walk any distance with his usual activity. Pain in body and rheumatic complications were absent. Sensory organs were perfect as to functions. For many years he was a leader in a church choir, but the

vocal cords for the past year did not respond with their usual vigor. After ten days' treatment the entire strength of the system was restored, and locomotion became as perfect as for years past, the voice also regained its power and tone, and he returned to his usual duties and responsibilities with ease and comfort.

CASE IV.—H. G., aged seventy-eight years, was a tall, spare man, had been a patent solicitor for a period of forty years, during the greater part of which time he enjoyed excellent health. Family history was unimportant: his parents enjoyed a good old age. Social surroundings were favorable. Alcohol and tobacco had been only used in moderation. Digestive power was moderately active, also the alimentary canal. Other functions of the system were undisturbed. The patient was of neurosanguine temperament, with alert manner. Latterly his expression had been one of anxiety and depression. As to the circulatory system, he experienced for several months a feeling at times of faintness, with feebleness of cardiac action, but unattended by cardiac murmur. Pulse became weak, with low tension between beats, but no thickening of vessel walls. Respiratory system presented no abnormality, except at times defective power as to thoracic expansion. Integumentary system was natural. Disturbance of equilibrium as to gait, except slow and weak for some months, such condition being gradually developed, was absent. Cerebral and mental functions were normal. Sleep was usually composed, and no indication of lesion in sensory centres could be observed. Pupils were of normal size and acted naturally. Some years ago he experienced weakness in sight, which under neurotone treatment greatly improved. On September 13, 1906, he was placed under treatment, which was given every third day for four weeks. At the expiration of this time a marked change for the better was undoubted, and in six weeks he increased in weight fully two pounds. He now walks vigorously, feels in excellent health and spirits, and conducts his business with usual mental and physical activity.

The daily, in fact the hourly, changes in the component parts of the human body are mysterious and difficult to define and nowhere more so than in the nervous system, the centre of thought, intellectual power, and locomotion. My object in producing

this paper is to sift a portion of the wheat from the chaff, and define a few of the limitations and possibilities of electricity. One point is certain; where damage to neurones or their nuclei have cut muscle fibres off from the normal source of stimulating energy, electricity is of little account, as far as maintaining muscular contractility is concerned. The reaction of degeneration is characterized by loss of excitability in the nerves and of the excitability to rapidly interrupted currents in the muscles. The reaction of degeneration is of great moment, and when present, a lesion in some part of the nervous tract is readily diagnosticated. In such conditions, electrolysis is useless. In nerve degeneration, when the induced current fails to meet with any response, it is called the reaction of degeneration. Weakened muscle cannot be strengthened by too strong a current, and such action must be avoided. So also with weakened nerve tissue. The power of the current must be graduated in proportion to the strength of either muscle or nerve.

"There is a great probability that a nervous impulse may be a change propagated by electrical agency, and even in its essential nature, an electrical phenomenon, a traveling and temporary dislocation of preexisting discrete particles, and not a traveling process producing new and differently gifted particles from the old." It is as solutions of electrolytes confined to minute cylinders that nerve fibres have a most important interest, and yet the characters of these solutions are beyond the reach of methods of ordinary chemical investigation. In the transmission of the electric current, it is well to be aware of the remarkable discovery of du Bois-Reymond, that the whole longitudinal surface of the individual nerve fibre is probably equally posi-

tive and the whole transverse surface uniformly negative. In order to intensify the conduction of the electric current, moisture is not only necessary externally, but is well provided for internally, as the nerve fibre is, throughout, a moist conductor. Nerve fibres are in fact only finely drawn processes of cells, containing inorganic salts within them, and the electrical conductivity is provided by the electrotonic currents and by their distribution. The axis cylinder of the nerve fibre is a better conductor than the tissues which ensheath the fibre, and more electricity, in fact, is carried or conveyed along the axis cylinders than is at the same time carried by the other tissues of the nerve. The electrical phenomena of nerve depend entirely on the inorganic salts which it contains, and from recent investigations it has been proved that the nerve trunk has three kinds of conducting material, an external medium of poor conductivity, a dividing membrane, and an internal solution of conductivity of a higher order than that of the external solution.

Recent investigations as to the physical conditions present within the nerve fibre, in the axis cylinder, have pointed out the existence of a remarkable condition of proteid material in a state of colloid solution, in some way a possible store of potential energy. In this direction, demonstration of the potassium ring of McCallum, surrounding granules within the nerve fibre, is most interesting and important, in relationship with solid colloid masses in aqueous solutions of salts. Such electrolytes, even by a limited degree of motion, tend to diminish the usefulness of an electrical current, transmitted through the colloid solution. A single fact, which dominates all, is that nerve is a material adapted for the transmission of energy, from point

to point, throughout the entire system, resting upon the undoubted presence of inorganic salts, as permanent constituents of the axis cylinder.

In no part of the human system are the irregularities of life more marked than in the alimentary canal, where the defenses of the organism permit the ingress of bacterial toxines. In this tract the blood making process becomes interrupted through the nonelimination of normal nerve power. Under such circumstances the perfectly stable nervous system is a rarity. Here particularly electrolysis becomes an important factor, giving new life and activity by establishing beyond doubt an average neuropsychic equilibrium. An important fact demonstrated clearly is that blood can actually be made by electricity, by stimulating through the abdominal walls the ganglia that take part in the process of blood formation.

A most important factor in the production of intestinal trouble is rapid eating of food. Man's efficiency in the duties of life is due in a great measure to the precautions in the use of suitable food, guarding rigidly the varied processes of digestion. Clearness of brain and strength of muscle are gained by living close to Nature. How frequently food leaves the stomach for the alimentary canal unconverted into normal chyme! This semidigested material gradually produces results far reaching in character. Dilatation of the colon, partial or general, frequently follows. The gas generated in the dilated colon, the outcome of imperfect assimilation, reflects a poisonous influence on the alimentary ganglia of the nervous system. About this attractive region takes place the mysterious conversion of vegetable and other food products into blood. The nervous system plays an important part in this remarkable

chemical transformation, histogenetic in character. This entire process is subject to defeat by surrounding abnormal conditions. A gradually debilitated state of the system frequently follows, marked by moderate œdema of the extremities entirely outside of cardiac, hepatic, or renal complications. Under such circumstances, the local application of electricity to the abdominal walls brings about gradually a decided change for the better, the result of restored energy to the ganglionic centres, marked by subsidence of the dilated colon and the gradual and complete disappearance of serosity in the legs, owing to increased activity of the absorbents. I have frequently observed in regions of the limbs a lessened degree of sensation to the electric current of short duration. This defective electric response is interesting in the light of the *clefts*, or *indentations* in the medulla of the axis cylinder, defined as small irregular masses, separated by fluid (Foster, *Physiology*, page 122). Such conditions may account for an imperfect nervous impulse, the importance of which cannot be overestimated, provided the sudden return of complete sensation is the result of electrolytic action, restoring the continuity of the medulla of the axis cylinder.

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